Chapter 10

Weather Observation

Introduction

The people who "go down to the sea in ships" fight a continuous close battle with the elements that make up the weather. A mariner's watch of weather conditions is of greater importance than it is to most people ashore. Accurate weather forecasting may not be as vital now as it was in the days of the sailing ships, but situations still arise when the safety of a ship and the lives of its crew depend on the evasive action taken to avoid the full fury of a storm. Even when actual safety is not considered, possible damage to the ship's boats and gear must be minimized by extra security measures taken well in advance of an approaching storm.

The action taken by ships may be based on the latest weather information compiled and broadcast by the appropriate Naval Oceanographic Center. The oceanographic centers base their predictions largely upon the reports of weather conditions received from ships at sea. An intelligent weather report from a ship can be made only by a person capable of accurately observing and (to some extent) interpreting weather conditions. Aerographer's mates are charged with this duty, but not all ships carry them. On a ship that doesn't have an Aerographer's Mate aboard, the weather observation duties are the responsibility of the Quartermasters. This chapter, then, is concerned with the weather and the way it is observed and reported.

Objectives

The material in this chapter will enable the student to:

- Measure, convert, and record barometric pressure.
- Determine apparent wind, relative wind, and true wind using anemometers or visual estimation.
- Identify cloud types and match them with their correct heights.
- Measure temperature, dew point, and relative humidity.
- Convert temperature to Celsius or Fahrenheit.
- Observe and report weather conditions using form CNOC 3140/8.
- Describe weather conditions associated with fronts.
- Recommend course of action to evade storms.

Topics

The Atmosphere

Composition

The atmosphere (air) is a mixture of independent gases. Near the surface of Earth, the percentages by volume of the various constituents are approximately 78% nitrogen, 21% oxygen, 1% argon, and traces of other gases such as carbon dioxide, hydrogen, neon, and helium. Water vapor, which has been omitted from the foregoing list, is found in relatively small but widely varying amounts; 1% of the total atmosphere may be taken as the average figure. The quantity of water vapor present is much greater in equatorial regions than it is in polar regions and greater over the ocean than over land. The atmosphere has definite weight, called atmospheric pressure, and is measured by an instrument called a barometer.

Changes in the Weather

Large-scale changes in temperature, pressure, and water vapor content of the atmosphere cause changes in the weather. Warm air is lighter in weight and can hold more water vapor then cold air. Moist air with a temperature of 50°F is lighter than drier air of the same temperature because water vapor is lighter than air. Cold or heavy air has a tendency to flow toward and take the place of warm or lighter air; and, as the air begins to move, other forces come in to play, making the movement of air masses and weather rather complex. You can readily see that temperature, humidity, and atmospheric pressure are all factors in considering the weather.

Circulation of the Wind Upon Earth

The Basics

The following paragraphs deal with the general (surface) circulation with prevailing winds and nearby permanent pressure systems of belts. (See fig. 10-1). In the Northern Hemisphere, the circulation is clockwise about high-pressure areas (called anticyclones) and counterclockwise about low-pressure areas (called cyclones). The reverse is true in the Southern Hemisphere. At times, confusion arises from the meaning of wind direction. Wind is always named by the direction *from* which it is blowing.

The Doldrums

The equatorial belt of light and variable winds between the northeast tradewinds of the Northern Hemisphere and the southeast trade winds of the Southern Hemisphere is called the doldrums, or the intertropical convergence zone.

The doldrums may vary in position. They tend to move north and south of the Equator with the Sun, though more of the area is generally located slightly north of the Equator. In the doldrums, the temperatures are high and the wind convergent (a net inflow of air into the area), which causes greater rainfall.

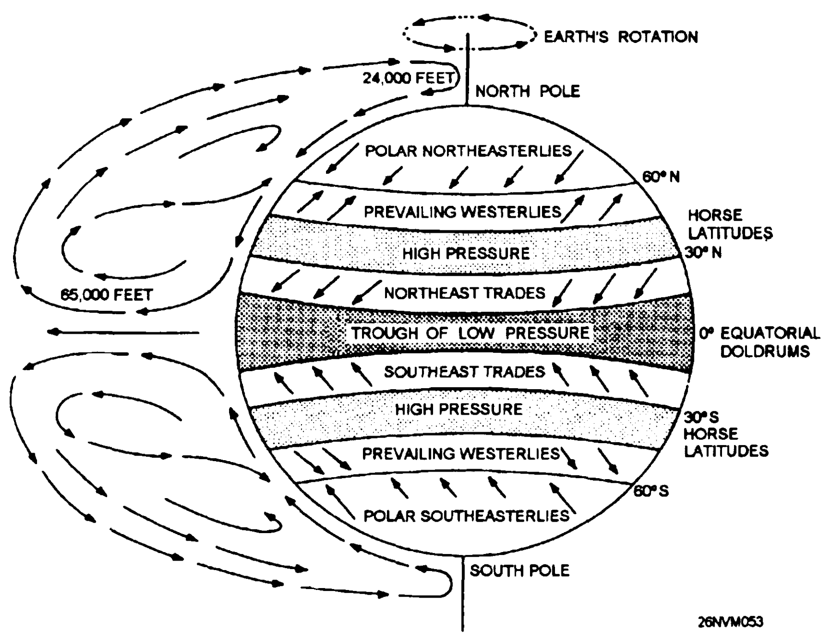

Figure 10-1. General circulation of air.

Circulation of the Wind Upon Earth, Continued

The Tradewinds

The tradewinds are found just north and south of the doldrums. Whenever the doldrums are absent in some part of the equatorial region, the tradewinds of the Northern and Southern Hemispheres converge, causing heavy rain squalls. A feature of the trade belt is the regularity of the systems, especially over the oceans. The wind blowing above and counter to the trade is called the *ANTITRADE.*

Horse Latitudes

The areas of the subtropical high-pressure cells, where the winds are light and variable are about 30°N to 40°N and 30°S to 40°S. They are called the *horse* latitudes. Fair weather is characteristic of this region, due to the descending air. The pressure decreases outward from this area, and the prevailing westerlies are on the poleward side, with the tradewinds on the equatorial side.

Prevailing Westerlies

The *prevailing westerlies,* which are on the poleward side of the tradewinds are persistent through the midlatitudes. In the Northern Hemisphere their direction at the surface is from the southwest, and in the Southern Hemisphere from the northwest. This is a result of the deflection caused by the Coriolis force as air moves poleward. The Coriolis effect is the apparent force exerted by the rotation of Earth. The front zone lies poleward of the prevailing westerlies.

Polar Region Winds

In the polar cells, polewards of the polar front zone, the surface winds are known as the polar easterlies (polar northeasterlies at the North Pole and southeasterlies at the South Pole). They move the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. They are very shallow due to the low temperatures and are overlain by the westerlies. This circulation pattern is temporarily disrupted by the migratory pressure systems in all areas but returns to the original pattern.

Cloud Formations

The Basics

The atmosphere always contains, in greater or smaller amounts, tiny particles, such as dust from roads, desert sand, plant pollen, salt particles from oceans, and factory smoke. These fragments are hygroscopic nuclei, the term means particles that readily condense moisture. A cloud is merely a mass of hygroscopic nuclei that has soaked up moisture from the air.

The heat generated by the Sun's energy causes earthbound moisture to evaporate (turn into water vapor). Water vapor is lighter than air; thus, it rises. If the air it passes into is cold enough, the vapor condenses; that is, it turns back into moisture. The water droplets that result from this process cling to the hygroscopic nuclei. Many of these water-soaked nuclei bunched together form a cloud. Fog is the same in principle, but it's a cloud on the ground.

Changes in atmospheric conditions account for the many different shapes of clouds and for their presence at various altitudes. Formations of clouds give clues concerning the existing forces at play in the atomsphere. That's why you must keep an accurate record of cloud genera (types).

Cloud Etage

With respect to clouds, the atmosphere is broken down into three layers or *etages*. In the middle latitudes or temperate region, the low etage is from the surface to 6,500 feet; the mid etage, from 6,500 feet to 18.500 feet; and the high etage, from 18,500 feet on up to near 45,000 feet (fig. 10-2). The limits of the etages are generally lower in the polar regions (mid etage, from 6,500 to 10,000 feet and high etage from 10,000 to 25,000 feet) and higher in the tropics (mid etage from 6,500 to 20,000 feet and high etage from 20,000 to 60,000 feet).

The low-etage cloud may be cumuliform, such as the cumulus genera or cumulonimbus (identified by their size and extent of development); stratiform, such as the stratus; or have mixed characteristics, such as the stratocumulus. The mid-etage cloud genera are mostly identified with the prefix *alto.* The mid etage contains the cumuliform clouds, such as altocumulus, and the stratiform clouds, such as altostratus and nimbostratus. The high-etage cloud genera contain the prefix *cirro.* Cumuliform clouds in this etage are called cirrocumulus, while stratiform clouds are called cirrostratus. Another form of cloud found only in the high etage is the cirriform clouds that are the normally thin, wispy or hairlike ice-crystal clouds that can be defined as neither cumuliform nor stratiform, but are simply called cirrus clouds.

Take a moment to study figure 10-2, which shows many of the cloud genera and their associated heights above ground.

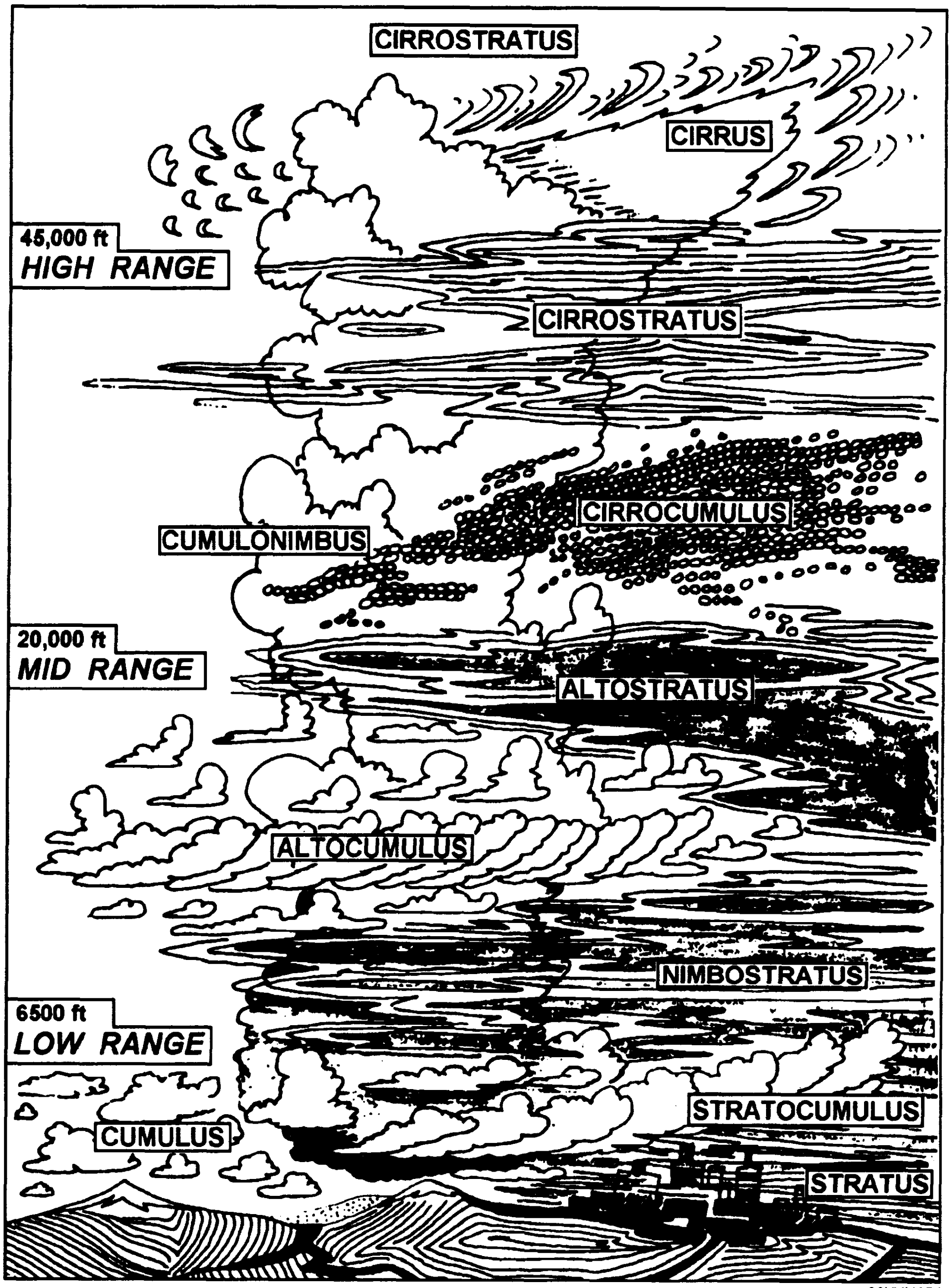

Figure 10-2. Cloud genera and associated heights.

Cloud Characteristics

High-Etage Clouds

Cirrus (CI) clouds are detached clouds of delicate and stringy appearance, generally white in color, without shading. They appear in the most varied forms, such as isolated tufts, lines drawn across the sky, branching featherlike plumes, and curved lines ending in tufts.

Cirrus clouds are composed of ice crystals; hence their transparent character depends upon the degree of separation of the crystals. Before sunrise and after sunset, cirrus clouds may still be colored bright yellow or red. Being high-altitude clouds, they light up before lower clouds and fade out much later. Cirrus clouds often indicate the direction in which a storm lies.

Cirrocumulus (CC) clouds, commonly called mackerel sky, look like rippled sand or like cirrus clouds containing globular masses of cotton, usually without shadows. Cirrocumulus clouds indicate that a storm probably is approaching.

Cirrostratus (CS) clouds are a thin whitish veil that does not blur the outlines of the Sun or Moon but gives rise to halos (colored or whitish rings and arcs around the Sun or Moon; the colored arcs appear reddish on the inside edges). A milky veil of fog (thin stratus) and altostratus are distinguished from a veil of cirrostratus of similar appearance by the halo phenomenon, which the Sun or Moon nearly always produces in a layer of cirrostratus. The appearance of cirrostratus is a good indication of rain.

Mid-Etage Clouds

Altocumulus (AC) clouds are a layer (or patches) composed of flattened globular masses, the smallest elements of the regularly arranged layer being fairly small and thin, with or without shading. The balls or patches are usually arranged in groups, lines, or waves. Sometimes a corona (similar to a halo but with the reddish color on the outside edges) may be seen on the altocumulus. This cloud form differs from the cirrocumulus by generally having larger masses, by casting shadows, and by having no connection with the cirrus forms.

Altostratus (AS) looks like a thick cirrostratus, but without the halo phenomena, the altostratus is a fibrous veil or sheet, gray or bluish in color. Sometimes the Sun or Moon is obscured completely. At other times they can be vaguely seen, as through ground glass. Light rain or heavy rain may fall from a cloud layer that is definitely altostratus.

Low-Etage Clouds

Nimbostratus (NS) clouds are a dark gray-colored amorphous (shapeless) and rainy layer of cloud. They are usually nearly uniform and feebly illuminated, seemingly from within. When precipitation occurs, it is in the form of continuous rain or snow, but nimbostratus may occur without rain or snow. Often there is precipitation that does not reach the ground, in which case, the base of the cloud may extend into the low-cloud family.

Stratocumulus (SC) clouds are layer or patches of clouds composed of globular masses or rolls. The smallest of the regularly arranged elements are fairly large. They are soft and gray with dark spots.

Stratus (ST) clouds are a low, uniform layer of clouds, resembling fog, but not resting on the ground. A veil of stratus gives the sky a hazy appearance. Usually, only drizzle is associated with stratus. When there is no precipitation, the stratus cloud form appears drier than other similar forms, and it shows some contrasts and some lighter transparent parts.

Cumulus (CU) clouds are dense clouds with vertical development. Their upper surfaces are dome-shaped and exhibit rounded projections, and their bases are nearly horizontal. Stratocumulus clouds resemble ragged cumulus clouds in which the different parts show constant change. Strong updrafts exist under and within larger cumulus formations. In fact, cumulus clouds, like other forms of vertically developed clouds, are caused by updrafts.

Cumulonimbus (CB) clouds are heavy masses of cloud, with towering vertical development, whose cumuliform summits resemble mountains or towers. Their upper parts leave a fibrous texture, and often they spread out in the shape of an anvil.

Cumulonimbus clouds are generally associated with showers of rain or snow, and sometimes produce hail. Thunderstorms are always associated with cumulonimbus. The bases of the cumulonimbus may be anywhere from 1,600 feet to 6,500 feet. Although you would rarely see all types at any one time in nature, quite frequently you may observe two or three layers of clouds of different types at one observation.

Fog

Fog at sea is frequently formed through the process known as *advection* (the transport of an atmospheric property solely by the mass motion of the atmosphere). If warm air that passed over warm water moves to an area where the water is colder, fog is likely to develop in the latter region. The temperature of seawater is fairly uniform within a large area and accounts for fog that often lasts for many days and nights at sea.

The great fog banks of the North Atlantic, as well as those around the Aleutians, demonstrate what can happen when two adjacent bodies of water have markedly different temperatures. In the vicinity of Newfoundland, warm air that has passed over the warm Gulf Stream quickly turns to fog when it strikes the inshore current of very cold water that flows southward along the coastline. Off Alaska, the same situation prevails when the air from over the warm Japanese stream (Kuroshio) comes in contact with the cold southward-flowing waters of the Bering Sea (Oyashio).

Along coastlines special conditions may exist. Onshore winds blow warm, moist air inland from the ocean. The waters adjacent to the coast are sometimes colder than those farther offshore. At night an onshore wind lays down a thick blanket of fog that often extends some distance inland. The fog hangs on until the Sun heats up the land enough to evaporate the droplets or until an offshore wind drives the fog blanket away.

How can you tell when a fog is on the way or in the process of formation? The difference between the temperature shown by the wet bulb and the dry bulb of the psychrometer, called wet-bulb depression, is your fog indicator.

In general, fog forms when the depression is 4° or less. A continuous record of the wet-bulb depression serves as a fairly reliable predictor of fog.

Atmospheric Pressure

Weight

The layer of atmosphere that surrounds us exerts a pressure of approximately 15 pounds per square inch at sea level. The weight of the atmosphere varies with the presence of water vapor as well as with temperature and height above sea level. Variations in atmospheric pressure are measured by an instrument called a barometer.

Aneroid Barometer

The aneroid (dry or no fluid) barometer (ML-448) (fig. 10-3) needs no correction except for altitude. It contains a small metallic cell, called a syphon cell, which encloses a partial vacuum. As atmospheric pressure increases, the syphon cell contracts; as pressure decreases it expands.

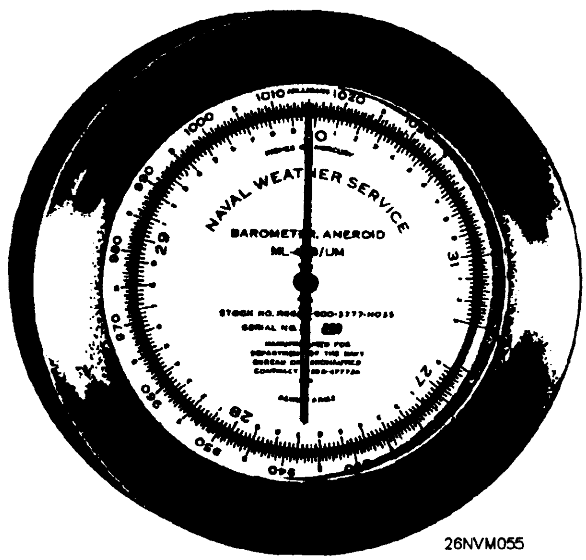

Figure 10-3. Aneroid barometer.

As the syphon cell expands and contracts, it communicates motion to an indicating pointer on a graduated scale.

The aneroid barometer (ML-448) is graduated in inches of mercury and in millibars (mb). Both inches and millibars are measurements of the weight of the atmosphere at a given time or point. The average atmospheric pressure at Earth’s surface is 29.92 inches or 1013.2 millibars.

Aneroid Barometer, continued

Figure 10-4 shows comparative readings on the inch and millibar scales.

The aneroid barometers normally can be read no closer than 0.01 inch.

Aneroid barometers are the standard pressure-indicating instrument aboard ship and the type of barometers that Quartermasters will encounter most frequently.

Barometers should be calibrated yearly in accordance with PMS.

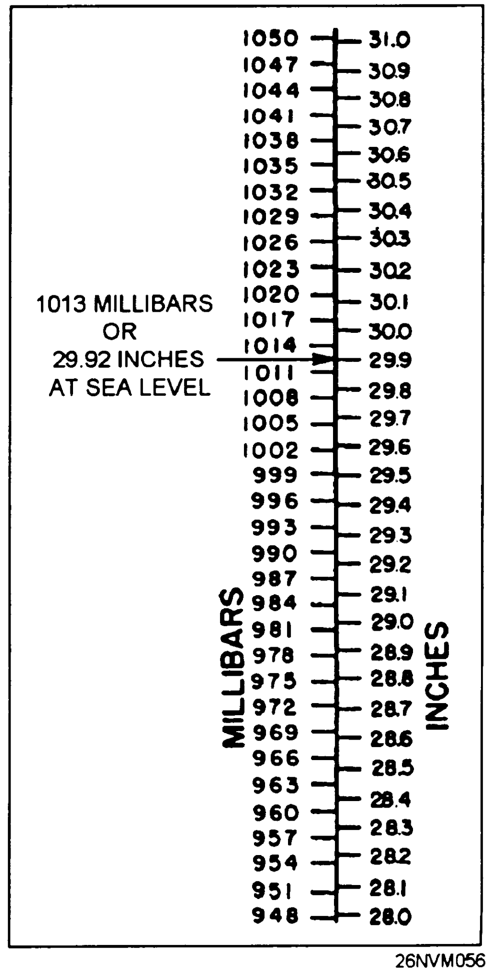

Figure 10-4. Inches and millibars.

Significance of Pressure

A chart of the atmospheric pressure over a large area of Earth as surface at any given time tells you which way different air masses (an air mass is a large body of air that has common temperature and humidity characteristics) are moving. Some air masses originate in the cold polar regions; some, in the tropics. By the time they reach you, these air masses, called maritime air masses, have moved from vast bodies of water. Others, called continental air masses, have grown up over more or less dry land. Air masses carry along with them the temperature and humidity characteristics of the areas they crossed. Where distinctly different air masses touch, the boundary between them is called a *front* and is marked by cloudiness and precipitation.

Pressure Areas

Frontal Weather The atmosphere can produce weather in other ways, of course, but frontal weather, which is often violent, can be predicted from a chart of pressure systems. Figure 10-5 shows different types of pressure areas on a weather chart.

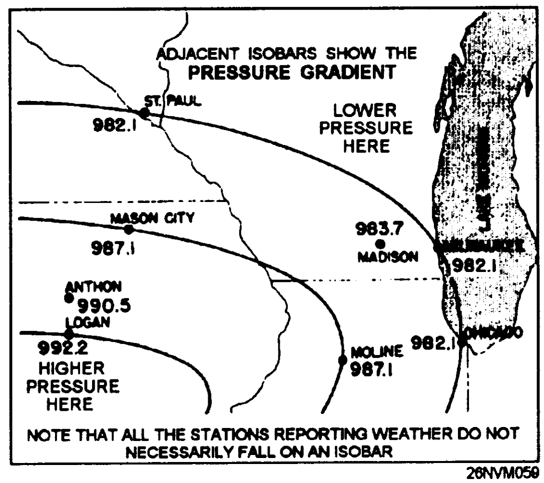

Figure 10-5. Sample weather map.

Isobars Atmospheric pressure is reported in millibars. One atmosphere equals 14.696 pounds per square inch, a bar equals slightly more than 0.98 atmosphere, and a millibar equals 1/1000 of a bar.

On weather charts, pressure is usually indicated in millibars (fig. 10-6). The lines shown in the figure are drawn through points of equal pressure and are called isobars.

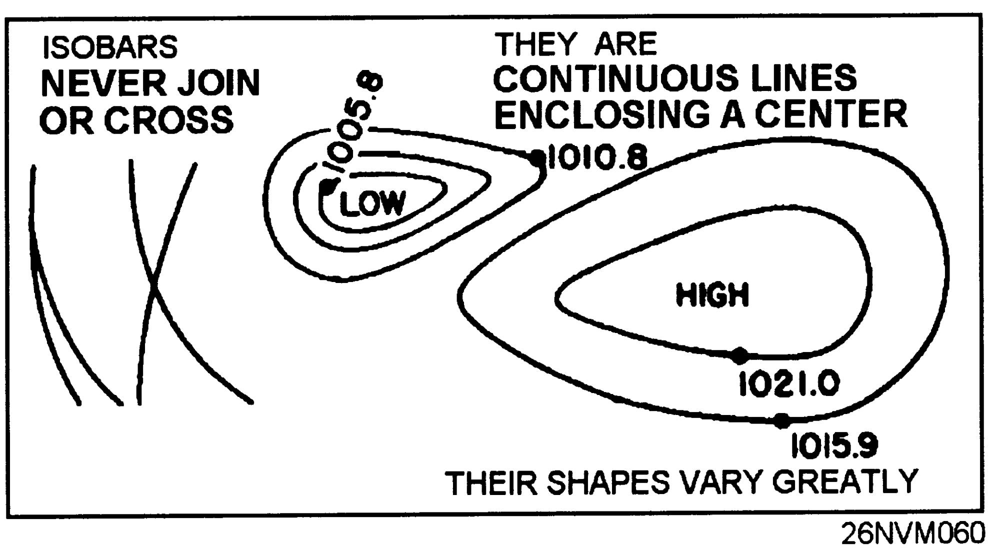

Figure 10-6. Shapes of isobars.

Isobars, continued

Usually, isobars are drawn for equal intervals of pressure (every 4 millibar for example), and frequently, isobars do not pass through reporting stations. Isobars never join or cross. Some may run off the chart, but others may close, forming irregular ovals that define the areas of highest and lowest pressure (fig. 10-6). Air (wind) flows from high-pressure areas to low-pressure areas. The strength of the wind depends upon two factors: the amount of difference in pressure and the distance of the high-pressure area (high) from the low-pressure area (low). These two factors combined are called pressure gradient. The greater the gradient, the stronger the wind. Thus, isobars can give a rough indication of the amount of wind. The closer an isobar is to another, the greater the amount of wind in that area. In figure 10-7, the isobars represent pressures of 992.2 mb, 987.1 mb, and 982.1 mb.

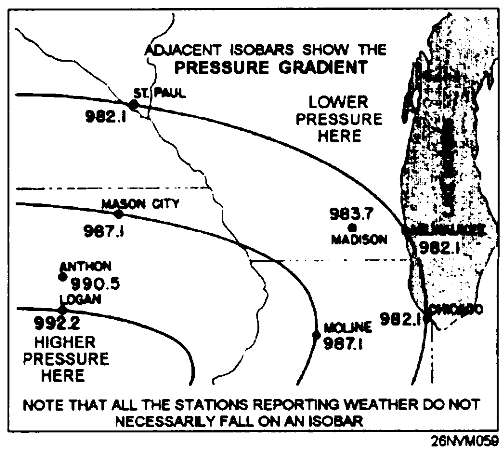

Figure 10-7. Isobaric patterns.

The spacing and shape of isobars are seen in figure 10-6, which also shows how complete isobars are formed. Isobars are always smoothed-out curves, usually making irregular ovals around the high- or low-pressure center.

Refer to figure 10-7 and you can see that only part of each isobar (the upper right portion of the oval) appears in the diagram. In this pressure system, that area of greatest pressure is at the system's center. This high-pressure area is also called a high or an anticyclone. If the pressure is 992.2 mb at Chicago, 987.1 mb at Moline, and 982.1 mb at Logan, the area of lowest pressure is in the vicinity of Logan. This area would be a low, or a cyclone.

Warm Fronts

Active warm fronts are generally located in pressure troughs on surface charts. See figure 10-8. The troughs are not as pronounced as those observed with cold fronts; therefore, other meteorological elements are used as follows in locating warm fronts accurately:

1. **Pressure tendencies.** Pressure usually falls for an appreciable length of time before the front passes. Normally it is steady after passage. The tendencies in advance of the front are therefore a steady or unsteady fall. A warm frontal passage is usually indicated by a tendency.

2. **Wind.** The wind in advance of a warm front in the Northern Hemisphere is usually from the southeast, shifting to southwest after passage. The wind speed normally increases as the front approaches. The wind shift accompanying a warm front is seldom as abrupt as with a cold front.

3. **Cloud forms.** Warm fronts are nearly always well defined by tropical stratified clouds. They are generally cirrus, cirrostratus, altostratus, nimbostratus, and stratus with the cirrus appearing as much as 1,000 miles before the actual surface passage. The cloud types that form after passage of the warm front are typical of the warm air mass.

4. **Precipitation.** The precipitation area of warm fronts extends about 300 miles in advance of the surface front. Precipitation occurs mainly in the form of continuous or intermittent rain, snow, or drizzle. However, when the warm air is connectively unstable, showers and thunderstorms may occur in addition to the steady precipitation.

5. **Temperature and dew-point chances.** Abrupt temperature changes, like those characteristic of cold fronts, do not accompany the warm frontal passage. Instead, the *temperature* change is gradual. It starts increasing *slowly* with the approach of the front and increases slightly more rapidly with the passage. The dew point is normally observed to rise as the front approaches, and a further increase follows the frontal passage when the air in the warm sector is of maritime origin.

6. **Visibility and ceiling.** The visibility and ceiling are normally good until the precipitation begins. Then they decrease rapidly. Dense fog frequently occurs in advance of a warm front. These conditions improve after the front passes.

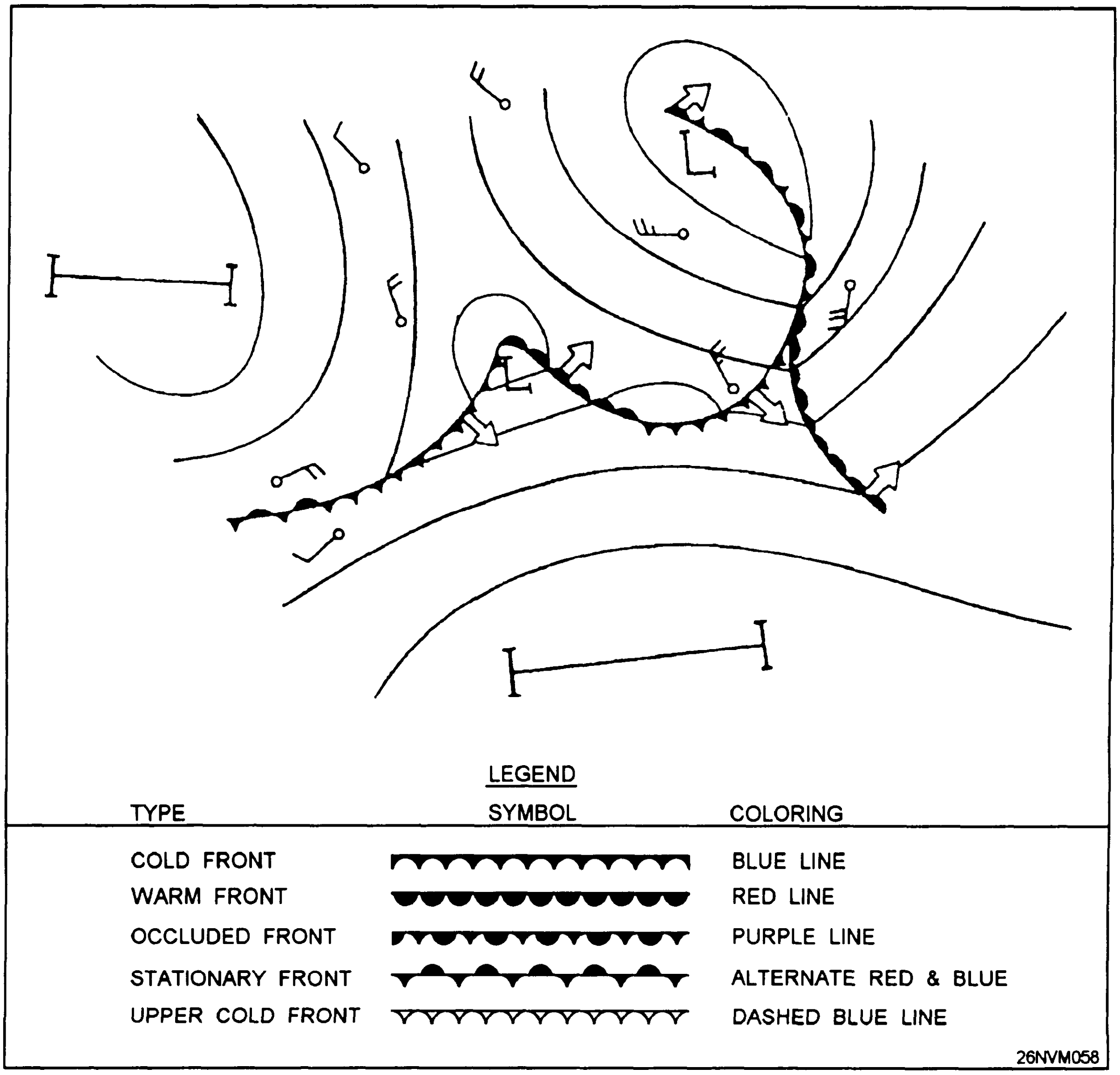

Figure 10-8. Designation of fronts on weather maps.

Cold Fronts

Cold fronts are normally located in well-deemed pressure troughs whenever there is a marked temperature contrast between two air masses. In most cases, a careful analysis of the isobars indicates the correct position of the pressure trough that contains the front. This method of isobaric analysis is frequently the only possible means of locating fronts over ocean areas or regions of scanty surface reports. Other indications of cold fronts can be classified as prefrontal, frontal, or postfrontal as follows:

1. **Pressure tendencies.** In advance of cold fronts, the tendency characteristic is usually indicated by a steady or unsteady fall. The isobars of falling pressure in advance of the front usually form an elongated pattern approximately parallel to the front. After passage of the front, the tendency generally shows a steady rise.

2. **Wind.** With the approach of the front, the wind is normally from the south or southwest in the Northern Hemisphere, veering to parallel the front. At the passage, the wind generally shifts abruptly to the northwest. Very gusty winds frequently occur at the frontal passage and usually after passage.

3. **Cloud forms.** In advance of cold fronts, the cloud types are typical of the warm air. Towering cumulus, cumulonimbus, stratocumulus, and nimbostratus are associated with the passage. After passage, these cloud forms may prevail for several hundred miles with the slow-moving cold front. Very rapid clearing conditions are associated with the fast-moving cold front after passage. Well back in the cold air in both types of cold fronts, the only clouds normally found are fair-weather cumulus.

4. **Precipitation.** Showers and sometimes thunderstorms occur as a cold front passes. Continuous precipitation is observed for some hours after passage of a slow-moving cold front. Showers and thunderstorm activity of short duration will occur with the passage of a fast-moving cold front, followed by very rapid clearing conditions.

Cold Fronts, continued

5. **Temperatures.** Temperature is relatively high before passage. After passage, the temperature decreases very rapidly with slow-moving fronts. Such a rapid temperature change does not accompany the passage of fast-moving cold fronts; the real temperature change is usually seen some distance (as far as 50 to 100 miles) behind the front.

6. **Dew point.** The dew-point temperature generally helps to locate fronts. This is especially true in mountainous regions. A drop in the dew point is observed with the passage of either type of cold front.

7. **Visibility and ceiling.** With the approach and passage of a slow-moving cold front, the visibility and ceilings decrease and remain low after the passage until well within the cold air. Fast-moving cold fronts are preceded by regions of poor visibility and low ceilings due to shower activity. After passage of fast-moving cold fronts, the ceiling rapidly becomes unlimited and the visibility unrestricted.

Occluded Fronts

Because the occlusion is a combination of a cold front and a warm front, the resulting weather is a combination of conditions that exists with both. Ahead of a cold-type occlusion, as the warm air is lifted, all clouds associated with a warm front are found producing typical prefrontal precipitation extensively for a distance of 250 to 300 miles. Typical cold front weather is found throughout the narrow belt in the vicinity of the surface front. However, the thunderstorms are less intense than those of a typical cold front. This occurs because the source of warm air has been cut off from the surface, and the energy received comes only from the warm air trapped aloft. Instability showers often follow the cold front when the cold air is unstable. The most violent weather occurs on the upper front for a distance of 50 to 100 miles north of the northern tip of the warm sector. After the occlusion has passed, the weather usually clears rapidly. The weather associated with the warm occlusion is very similar to that of the cold occlusion. With the warm occlusion, the high-level thunderstorms associated with the upper cold front develop quite some distance ahead of the surface front (up to 200 miles), and the weather band, in general, is wider (up to 400 miles). The air behind the cold front, flowing up the warm frontal surface, causes cumuliform-type clouds to form. In this area, precipitation and severe icing may be found. The most violent weather occurs on the upper front, 50 to 100 miles north of the northern tip of the warm sector.

Determining Wind Speed

For reasons previously discussed in this chapter and for reporting purposes, Quartermasters must be able to compute the direction and velocity of the true wind. The following discussion contains instructions for observing the wind speed and direction and computing true wind data (speed, direction, gusts, and shifts).

The movement of the ship affects the wind speed observed by both the ship's anemometers and hand-held anemometer. Relative wind is measured from the direction and speed from which the wind appears to be blowing. Relative wind seldom coincides with true wind because the direction and speed of the relative wind are affected by the ship's movement. For example, if your ship is heading north at 10 knots and true wind is blowing from the south at 10 knots, there appears to be no wind at all. In another example, your ship is heading north and the wind appears to be blowing in on the port bow, but the true wind is actually coming from the port quarter. In our discussion of the different types of wind, refer to the following explanations:

1. True wind (TW) is the velocity and direction from which the true wind is blowing.

2. Relative wind (RW) is the velocity and relative direction from which the wind is blowing in relation to ship's heading (SH).

3. Apparent wind (AW) is the velocity and true direction from which the relative wind is blowing. For example, if your ship is heading 090° and the relative wind is blowing in on your starboard bow (045°) at 15 knots, the apparent wind is from 135°T at 15 knots. The formula for apparent wind is: AW=RW+SH.

Wind speed (including gusts and squalls) is observed, computed, and reported in nautical miles per hour (knots) to the nearest whole knot. Since the true wind must be computed, the chance of committing an error is increased. The wind data reported is used as criteria for wind, storm, and high seas warnings. Care must be taken whenever computing true wind. Wind data can be observed using the following methods listed in order of preference:

1. Installed anemometer
2. Hand-held anemometer
3. Visual estimation

Installed Anemometers

An installed anemometer (fig. 10-9) is an instrument fixed somewhere aloft, usually at the masthead. The wind blows on a propeller attached to one end of a wind vane that pivots. The whirling propeller revolves a spindle, communicating with a synchro repeater on a pilothouse or chart house bulkhead. Figure 10-10 shows one type of synchro repeater.

The upper dial of the repeater is graduated in lo-degree intervals and shows the relative direction from which the wind is blowing. In this illustration the direction is about 287°. The lower dial indicates the relative wind speed (true wind speed when the ship is stationary). The wind speed dial in the illustration shows about 87 knots. This reading means that the force exerted by 87 knots of wind is whirling the anemometer propeller.

When using an installed anemometer, always compare the readings observed with the wind conditions as they appear outside. If two anemometers are installed, make sure that the windward anemometer is used.

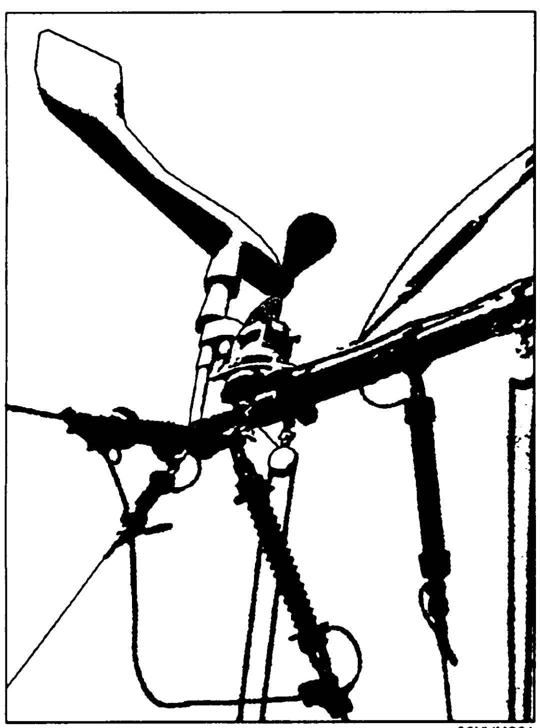

Figure 10-9. Installed anometer.

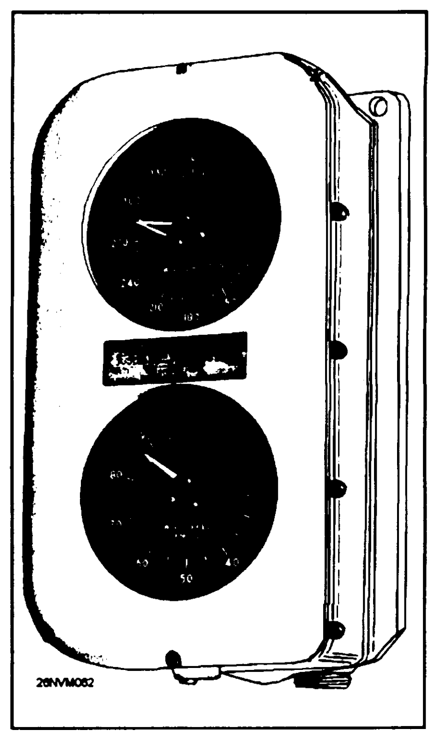

Figure 10-10. Synchro repeater.

Using Hand Held Anemometers

If anemometers are not installed or not working properly, or for some reason the readings are in doubt, the hand-held anemometer should be used. The Wind Measuring Set AN/PMQ-3 (fig. 10-11) is a hand-held anemometer. It is a combination wind direction and speed indicator. It indicates direction to 360° and speed from 0 to 60 knots. The speed indicator has two scales, graduated from 0 to 15 knots and 0 to 60 knots. To use the hand-held anemometer, you choose an observation point on the windward side of the ship, as far upwind as possible. For example, if the wind is from the stem, go aft; if it is from the bow, go forward. If possible, stand facing parallel to the ship's centerline and into the wind.

When you use the hand-held anemometer, follow the instructions given in the table below.

Step	Action
1.	Grasp the instrument by the handle and hold it in an approximately vertical position at arm's length with the sight at eye level.
2.	Aim the instrument at an imaginary point on the horizon. This is done by aligning the center of the slot in the front of the sight with the center of the strip between the two slots on the rear sight. Aim it as you would a gun.
3.	Press and hold the vane locking trigger. Note the reading on the 0 to 60 (upper) scale on the wind speed indicator. If the wind speed reading is less than 15 knots, press the range selecting trigger on the side of the housing, and observe the reading on the 0 to 15 scale. Care must be taken not to take the first reading on the 0 to 15 scale because a wind speed in excess of 15 knots may damage the anemometer.
4.	Note the motion of the wind vane as it moves between the extremes, and release the vane locking trigger when the vane is in the position of the predominant (average) wind direction. Carefully lower and tilt the anemometer and note the wind direction reading on the direction dial. If the wind is being observed facing aft, the direction must be converted in relation to the bow. Add 180° for directions from 0° through 90°. Subtract 180° for directions from 270° through 360°.
5.	Maintenance of the AN/PMQ-3 should be in accordance with PMS instructions.

Hand held Anemometer

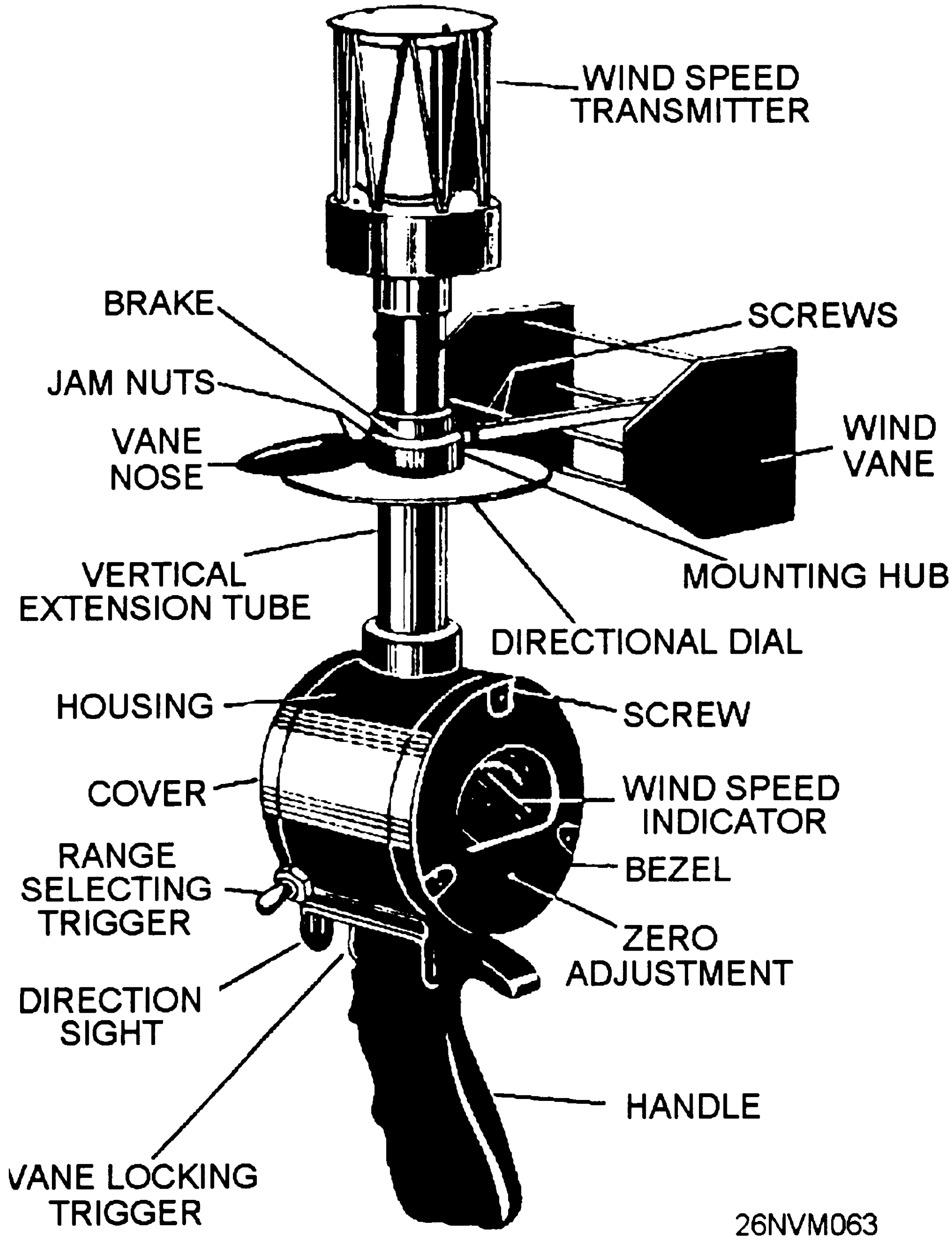

Figure 10-11. Hand-held anemometer.

Visual Estimation of Wind Speed

True wind direction may be observed by noting the direction from which ripples, small waves, and sea spray are coming. The direction is most easily found by sighting along the wave crests and turning 90° to face the advancing waves. The observer is then facing the true wind direction. You may estimate the true wind speed by noting the sea condition and referring to table 10-1, which is based upon the following assumptions and should be considered in arriving at an estimated true wind speed:

1. The wind has been blowing at a relatively constant speed and direction for the time indicated by table 10-1.

2. The fetch area (an area where waves are being generated by the wind) is unlimited.

Some factors that cause the speed estimation of the wind to be too low are as follows:

1. Winds have increased rapidly.

2. Offshore winds within the sight of land.

3. Moderate or heavy precipitation smoothing the sea surface.

4. Swell waves from varying directions.

Some factors that will cause the speed estimation of the wind to be to high are as follows:

1. Waves running into shallow water.

2. A decreasing wind speed. The relative wind speed and direction can be estimated by observing the ship’s flag, smoke, and rigging on the windward side of the ship. Table 10-1 should be used when you are using this method. Notice that this method gives you the relative wind and should be used only when the surface of the sea cannot be observed.

Knots	Beaufort Number	Wave Ht. in feet	Description	Sea Conditions
0	0	0	Calm	Sea smooth and mirrorlike.
1-3	1	1/4	Light air	Scalelike ripples without foam crests.
4-6	2	1/2	Light breeze	Small, short wavelets; crests have a glassy appearance and do not break.
7-10	3	1	Gentle breeze	Large wavelets; some crests begin to break. Occasional white foam crests.
11-16	4	3	Moderate breeze	Small waves, becoming longer; fairly frequent white foam crests.
17-21	5	6	Fresh breeze	Moderate waves, taking a more pronounced long form; many white foam crests; there may be some spray.
22-27	6	12	Strong breeze	Large waves begin to form; white foam crests are more extensive everywhere; there may be some spray.
28-33	7	*15	Near gale	Sea heaps up, and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
34-40	8	**20	Gale	Moderately high waves of greater length, edges of crests break, foam is blown in well-marked streaks along the direction of the wind.
41-47	9	***30	Strong gale	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to roll over; spray may reduce visibility.
48-55	10	***40	Storm	Very high waves with long overhanging crests. Foam in great patches is blown in dense white streaks along the direction of the wind. Visibility is reduced.
56-63	11	***50	Violent storm	Exceptionally high waves. The sea is completely covered with long, white patches of foam lying along the direction of the wind. Visibility reduced.
64 and over	12	***60+	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very much reduced.

* Duration time of 16 hours, not fully arisen

** Duration time of 20 hours, not fully arisen

*** Duration time of 24 hours, not fully arisen

Fetch is assumed to be unlimited.

26NVM064

Table 10-1. Estimating True Wind By Sea Conditions

Calculating True Wind Using the True Wind Computer

Once the relative wind direction and speed have been observed and the ship's course and speed recorded, the true wind can be computed. The True Wind Computer (CP 264/U) is the quickest and easiest method. Detailed instructions on the use of the True Wind Computer can be found in Chapter 10 of the *Manual for Ship's Surface Weather Observations,* NAVOCEANCOMINST 3144.1C.

Calculating True Wind Using the Maneuvering Board

The use of the maneuvering board (MB) is by far the most accurate method of determining true wind. The MB uses exact vectors to establish apparent wind and own ship's speed. The use of vectors makes this method more precise.

Information on calculating true wind can be found in Pub 217 *Maneuvering Board Manual*, therefore it will not be duplicated here. Pub 217 also contains solutions for finding desired wind, closest point of aproach, and several other vector solutions that are invaluable to the Quartermaster assisting the officer of the deck.

Computation Check

No matter which method of computation is used to derive the true wind direction and speed, the observer should check the results by applying the following rules:

Rule 1: The true wind direction is always on the same side of the ship as the apparent wind direction, but farther from the bow than the apparent wind direction.

Rule 2: When the apparent wind direction is abaft the beam, the true wind speed is greater than the apparent wind speed.

Rule 3: When the apparent wind direction is forward of the beam, the true wind speed is less than the apparent wind speed.

Temperature, Dew Point, and Relative Humidity

Measuring Temperature

You probably don’t need to be told that a thermometer is an instrument for measuring temperature. Generally speaking, it is a glass tube of small bore in which either alcohol or mercury expands and contracts with the rise and fall of the temperature of the surrounding medium. Most Navy thermometers are mercury-filled and practically all of them use the Fahrenheit (F) scale, where the freezing point of water is 32° and its boiling point is 212°. Temperature in meteorology, however, is sometimes expressed according to the Celsius (C) (formerly Centigrade) scale, where the freezing point of water is 0° and its boiling point is 100°.

You may be required to convert a Fahrenheit reading to Celsius, or vice versa. Knowing that 32°F = 0°C, to change a Fahrenheit reading to Celsius, you first subtract 32° and then multiply the remainder by 5/9.

Example: Say you want to change 41°F to Celsius. Subtracting 32° from 41° gives 9°. Multiply 9° by 5/9, and you get 45/9, or 5°C.

To change from Celsius to Fahrenheit, simply reverse the procedure. First multiply the Celsius temperature by 9/5, then add 32°. In the previous example, to change 5°C back to Fahrenheit, first multiply it by 9/5, which gives you 45/5, or 9°. Adding 32” gives you 41°F.

You may also use the following formulas:

$F = 1.8 \times C + 32$ (Multiply Celsius temp by 1.8, then add 32 to find Fahrenheit)

$C = F - 32$ divided by 1.8 (Fahrenheit minus 32, then divide by 1.8 to find Celsius)

A thermometer must be read properly to obtain an accurate result. First, if you must handle it, be sure that you do not touch the lower part of the glass containing the alcohol or mercury, because the heat from your body can affect the height of the mercury or alcohol column. Make certain that the top of the column is level with your eyes; otherwise you will be reading a higher or lower graduation than the one actually indicated. The top of the column is in the shape of a curve called a meniscus. It is the bottom of this curve that indicates the reading for an alcohol thermometer; the top, for a Mercury thermometer.

Measuring Dew Point and Relative Humidity

As already mentioned, the amount of water vapor the atmosphere can hold varies with the temperature. When the atmosphere contains all the water it can hold for a given temperature, the air is at the saturation point or humidity is 100%. If it contains 50% of what it could hold at that particular temperature, relative humidity is 50%. Relative humidity and dew point are determined through the use of a psychrometer.

Using the Sling Psychrometer

A psychrometer is simply two ordinary thermometers mounted together on a single strip of material. The bulb of one thermometer is covered by a water-soaked wick from which the water evaporates rapidly or slowly, depending on the amount of water vapor in the surrounding atmosphere.

Evaporation of water around the wet thermometer cools it. The amount of cooling depends on the rate of evaporation. The reading on the wet bulb is lower than the reading on the dry bulb except when the humidity is 100%, at which time both readings coincide. The difference between the wet-bulb and dry-bulb readings, when applied to tables developed for that purpose, results in relative humidity and dew point temperature.

The dew point is the temperature to which air must be cooled at constant pressure and constant water vapor content to reach saturation (100% relative humidity). When air is cooled to its dew point temperature, small water droplets condense on objects; that is, dew forms.

A sling psychrometer (fig. 10-12) is sometimes used to speed up the process of getting accurate wet-bulb and dry-bulb readings. The sling psychrometer can be whirled around to rapidly bring the wet bulb into contact with a great volume of air. This contact with air accelerates the evaporation rate. The person using the sling psychrometer should face the wind and should shield the instrument as much as possible from the direct rays of the Sun. The whirling should be repeated until no further change can be detected in the wet-bulb reading.

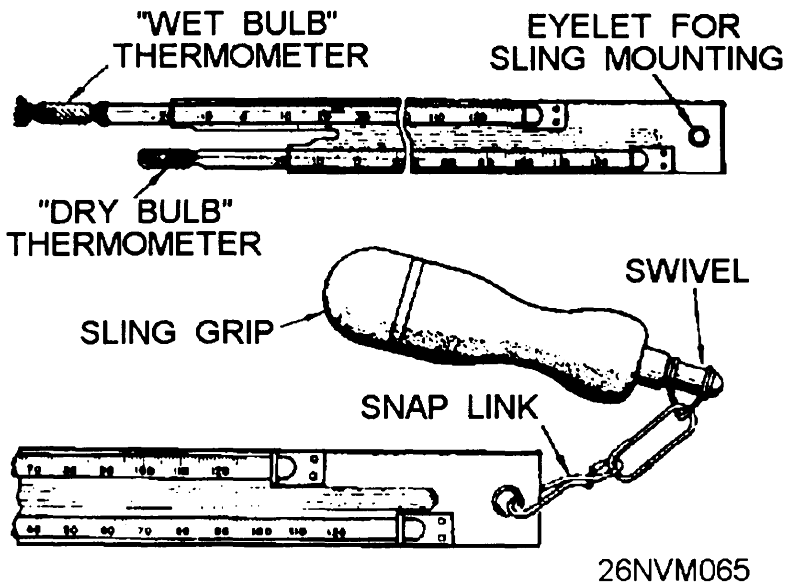

Figure 10-12. Sling psychrometer.

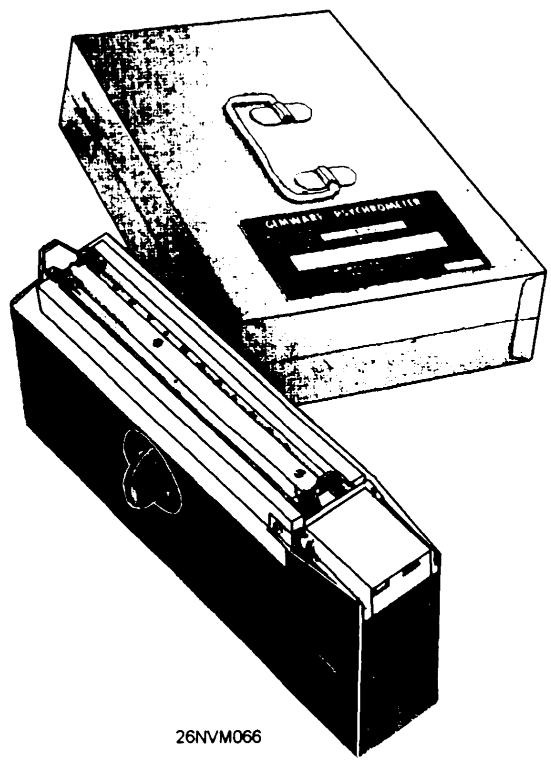

Figure 10-13. Electric psychrometer.

Electric Psychrometer

The Electric Psychrometer ML-450/UM (fig. 10-13) is a hand-held portable instrument that serves the same purpose as the sling psychrometer. As a Quartermaster this will probably be the only type of psychrometer that you use, since most ships do not carry the sling psychrometer. Three D-size batteries furnish power to a self-contained ventilation fan that aspirates the thermometer. The instrument also contains a lamp for nighttime readings. When using the electric psychrometer, select a shady area with no obstructions within 3 to 4 feet and face into the wind. Hold the instrument at waist height with the air intake pointing into the wind. Obtain the dry-bulb temperature first. When the ambient (circulating) air temperature is 50°F, or above, it is not necessary to energize the ventilation fan. The electric psychrometer should be exposed to the ambient air for at least 5 minutes before you read it. When no further decrease of the wet-bulb temperature is apparent, read the wet-bulb.

Finding the Dew Point

Use the psychrometer table 10-2 to compute the dew point. The *Manual for Ship's Surface Weather Observations* (NAVOCEANCOMINST 3144.1C) contains complete tables. Take a dry-bulb temperature of 70°F and a wet-bulb temperature of 60.5°F. The difference between the two readings, 9.5°F, is called the wet-bulb depression.

Example: To compute the dew point, you enter the wet-bulb reading (60.5°F). Go to the proper DEPRESSION column (9.5°F). Read the dew point temperature (54°F) directly from the intersection of the temperature row and the DEPRESSION column.

Table 10-2. Psychrometer Table

(Tabular values are dew points with respect to water)

Wet-bulb temperature (°F)	Depression of the wet-bulb thermometer (dry-bulb minus wet-bulb)																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
60.0	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53
60.5	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54
61.0	61	60	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54
61.5	61	61	61	60	60	60	59	59	59	58	58	58	58	57	57	56	56	55	55	55	55
62.0	62	61	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55
62.5	62	62	62	61	61	61	60	60	60	60	59	59	59	58	58	58	57	57	57	56	56
63.0	63	62	62	62	62	61	61	61	60	60	60	60	59	59	59	58	58	58	57	57	57
63.5	63	63	63	62	62	62	62	61	61	61	60	60	60	59	59	59	59	58	58	58	57
64.0	64	63	63	63	63	62	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58
64.5	64	64	64	63	63	63	63	62	62	62	61	61	61	61	60	60	60	59	59	59	58

26NVM067

Weather Observation and Reporting

Observation

Timely and accurate environmental observations are basic to the development of meteorological and oceanographic forecasts in support of fleet operations. Since the U.S. Navy may be committed to operations anywhere in the world, global observations of meteorological and oceanographic conditions are required. In remote areas (especially over oceans), environmental data are extremely sparse.

Accordingly, observations from Navy ships are particularly vital. In short, all ships at sea are required to take regular observations, but where ships are steaming in company or in close proximity (within 10 miles), the OTC may designate one of the ships to report observations for the group. Ships in port are required to continue regular weather observing and reporting by electronic means unless there is a nearby U.S. manned weather reporting activity.

In-port weather observing and reporting guard ship arrangements may be used for groups of ships at the discretion of the senior officer present. In such instances, the weather logs of exempted ships should bear a notation of the guard ship(s) and effective dates/times. Additional and special weather observations and reporting schedules that may be required in support of fleet operations are issued in pertinent operation plans and orders. Requirements for increased frequency of weather reporting by ships at sea in specific areas, particularly in areas where tropical disturbances are suspected or known to exist, should be issued as necessary by the area or force commander.

Recording the Weather

All ships taking surface weather observations must use the form CNOC 3140/8. This form contains two code forms and is divided into two sections, parts I and II.

Part I: Part I is the Ship Aviation Observation Code. This code is in the aviation observation code format with additional ship and sea data columns.

Part II: Part II is the Synoptic Code Message Format. It is determined from analyzing data from part I. The data is transmitted via radio message to the appropriate weather center.

Rules for Using CNOC 3140/8

CNOC 3140/8 is an official document and is the only record of weather encountered by the ship. All entries must be neat and legible. Care should be taken to avoid writeovers and partial erasures that confuse the legibility of the data entered. It is recommended that a folder or board be devised to protect the form between observations. An original and one duplicate of this form is required for each day's observations. The duplicate may be a rewritten copy, a carbon copy, or a suitable photocopy of the original form. The duplicate should be retained for a minimum of 1 year as part of the ship's record. All entries should be made with a black lead pencil (No. 2 or 2H) or an erasable ball-point pen, if available.

Corrections may be made by erasing the erroneous data only if the data has not been disseminated by any means (phone, radio, and message transmittal). Erase the erroneous data from all copies of the form and enter the correct data. When a carbon copy of the form is made, care must be taken to prevent carbon smudges on the duplicate copy.

If an error is discovered in encoded data after it has been transmitted, the erroneous data may not be erased. Using a red pencil, correct the error by drawing a line through the error and entering the correct data above it. Retransmit the observation with the corrections.

You must refer to *the Manual for Ship's Surface Weather Observations* (NAVOCEANCOMINST 3 144.1 Series) for step-by-step instructions on how to complete each column. A new form must be started at 0000 GMT each day. The 2355-59 observation will be the first observation of the new day. If the lines are filled in part I before the day is over, continue the observations on a new form. Continue to make entries in column 90 and part II on the first form.

In the following tables you will find an explanation for each column of both parts I and II of CNOC 3140/8. The example figure provided gives sample data from actual observations on part I and encoding for part II. Use the table and figure together to learn about the information contained within parts I and II.

CNOC · 3140/8 (REV 1/82) 0108-LF-031-4043

PART 1 SURFACE WEATHER OBSERVATIONS (SHIP / AVIATION) U.S.S.

TYPE (1)	TIME (GMT) (2)	SKY AND CEILING (HUNDREDS OF FEET) (3)	VISIBILITY (NAUT-MILES) (4)	WX & OBSTRN TO VIS (5)	SEA LEVEL PRES (MB) (6)	TEMP (1/10°F) (7)	DEW PT. (0°F) (8)	WIND DRCTN (9)	WIND SPEED (kts) (10)	WIND CHARACTER AND SHIFTS (11)	ALSTG (INCHES) (12)
SA	0059	15 SCT 200 BKN	7		044	48.0	37	21	08		
SA	0156	15 SCT 120 SCT 200 BKN	7		029	50.0	49	21	09		
SA	0255	12 SCT 80 BKN 100 OVC	6	F	023	51.8	51	20	15		
SA	0357	12 BKN 25 OVC	3	R-F	008	52.5	52	21	20		
SA	0458	10 BKN 18 OVC	1	R-F	997	53.0	53	20	25	G33	
SA	0558	5 BKN 12 OVC	½	R-F	989	54.0	54	20	30	G39	

REMARKS, NOTES, AND MISCELLANEOUS PHENOMENA (90)

PART II SYNOPTIC CODE ME

SECTION 0					SECTION 1					
BBXX	DDDD	$YYGGI_W$	99 $L_aL_aL_a$	$Q_cL_oL_oL_oL_o$	I_RI_xhvv	Nddff	1 S_nTTT	2 $S_nT_dT_dT_d$	4 PPPP	5 aPPP
BBXX		00	99		4		1	2	4	5
BBXX	TRANSMIT BUT	03	99		4		1	2	4	5
BBXX	DO NOT	01 06 4	99 454	71250	4 1294	82030	1 0122	2 0122	4 9958	5 7100
BBXX	ENCODE ON	09	99		4		1	2	4	5
BBXX	THIS FORM	12	99		4		1	2	4	5
BBXX		15	99		4		1	2	4	5
BBXX		18	99		4		1	2	4	5
BBXX		21	99		4		1	2	4	5

OPTIONAL: ENCODE ONLY IF SIGNIFICANT, UPON REQUEST, IF MODLOCKED OR ANCHORED.

26NVM068

	DATE 1 AUGUST 1985	QUARTERMASTER ✓ AEROGRAPHER'S MATE

REMARKS AND SUPPLEMENTARY CODED DATA DESIRED ORDER OF ENTRY: SFC based on obsc phenomena, remarks elaborating on preceding coded datd (13)	OBS INT (15)	STATION PRESSURE (Inches) (17)	SKY COVER TOTAL (21)	POSITION QLLII (A)	COURSE (B)	SPD (C)	SEA WATER (1/10C°) (D)	SEA WAVES PERIOD HEIGHT (E)	SWELL WAVES DIRECTION PERIOD HEIGHT (F)
	RLW	29.645	5	74525	230	18	10.0	0201	340601
	RLW	29.600	7	74525	230	18	10.1	0201	340601
	RLW	29.580	10	74525	230	18	10.3	0303	320602
	RLW	29.525	10	74525	230	12	10.7	0704	300802
	RLW	29.505	10	74525	230	10	10.9	0907	301003
	RLW	29.480	10	74525	230	10	11.2	1012	301205

SSAGE FORMAT

				SECTION 2									
7 wwW_1W_2	8 $N_hC_LC_MC_H$	9hh	//	222 D_sv_s	0 $S_nT_wT_wT_w$	2 $P_wP_wH_wH_w$	3 $d_{w1}d_{w1}$	$d_{w2}d_{w2}$	4 $P_{w1}P_{w1}H_{w1}H_{w1}$	5 $P_{w2}P_{w2}H_{w2}H_{w2}$	6 $I_sE_sE_sR_s$	ICE	$C_iS_ib_iD_iZ_i$
7	8	9	//	222	0	2	3		4	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	
7 6364	8 87//	9	//	222 54	0 0112	2 1012	3 30	//	4 1205	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	
7	8	9	//	222	0	2	3		4	5	6	ICE	

26NVM069

Column Number	Column Name	Explanation
1	Type	Either SA for hourly observation, or L for local observation (OBS). OBS are required for aircraft mishaps, collisions, man overboard.
2	Time	The time of the OBS always in GMT, must be recorded within 5 minutes, from 55 to 59 only!
3	Sky and Ceiling	The base of each layer of clouds and the type of sky cover associated with that layer. Always drop the last two zeros for the height. 15 BKN = 1500 feet and broken sky coverage at that layer.
4	Prevailing Visibility	This is the prevailing visibility reported to the nearest nautical mile.
5	Weather and Obstructions	Report items such as funnel clouds, hail, sleet, and fog.
6	Sea Level Pressure	Sea level pressure in millibars, entered in ten, units, and tenths. Enter 132 for 1013.2.
7	Temperature	Enter the dry-bulb temperature from the psychrometer.
8	Dew Point Temperature	The nearest dew point temperature to the nearest whole degree Fahrenheit.
9	Wind Direction	The direction from which the TRUE wind is blowing.
10	Wind Speed	Average wind speed at the time of OBS.
11	Wind Character	Gusting or squalling if appropriate.
12	Altimeter Setting	Station pressure reduced to sea level.
13	Remarks	Operationally significant information.
15	Observers Initials	Self explanatory.
17	Station Pressure	Pressure in inches.
21	Total Sky Cover	Estimated total sky coverage by clouds or other obstruction reported in tenths.

Column Number	Column Name	Explanation
(A)	Position	Abbreviated ship's position.
(B)	Course	General direction of the ship's course.
(C)	Speed	Ship's speed.
(D)	Seawater Temperature	Seawater temperature reported to the nearest 0.1 Fahrenheit.
(E)	Sea Waves, Period, and Height	The duration in seconds from the crest of one wave to the next and the average wave height. Sea waves are caused by local wind conditions.
(F)	Swell Waves, Direction, Period, and Height	The direction, duration in seconds from the crest of one wave to the next, and the average wave height.

CNOC 3140/8 Part II

Part II is designed to allow transmission via radio message of **encoded** weather information. The step-by-step instructions are printed in the *Manual for Surface Ship's Weather Observations* and will not be reproduced here. This manual should be consulted **each time an OBS is made.**

Additional Reporting Requirements

Ship's are required to submit encoded weather every 6 hours of GMT. For example a message should be sent at 0000, 0600, 1200, and so on.

If winds are greater than 33 knots, then messages must be sent with an immediate precedence every 3 hours.

Additional Information

As you may have guessed, weather, like navigation, is a complex subject on which volumes have been written. The objectives of this chapter are to prepare you to report the weather; however, senior QMs should thoroughly acquaint themselves with all aspects of weather. The AG series of TRAMANs is an excellent place to begin. Also Pub No. 9, *Bowditch*, has comprehensive information about weather and the mariner.